A comparison of the production costs, and the market introduction of Fischer-Tropsch oil and ethanol

C. Daey Ouwens*[a], A. Faaij[b]
[a]Eindhoven University of Technology, Faculty of Mechanical Engineering WH 3.129
P.O.box 513, 5600 MB Eindhoven, The Netherlands
Fax +31 40 2433445; C.Daey.Ouwens@tue.nl
[b]Utrecht University, Department of Science Technology and Society, Faculty of Chemistry

A comparison of the production costs of Fischer-Tropsch (F-T) oil and ethanol, based on the use of woody or grassy materials, has been made. The analysis includes practical and fundamental aspects related to the market introduction. Of the many fuels one can make of biomass, these two seem very promising [1, 2, 3, 4]. A key aspect is that both fuels can be very easily introduced into the existing infrastructure and vehicle fleets. However, for both fuels holds, that for the materials chosen, no large-scale plant has been built so far. This paper discusses the longer-term perspectives for both routes and in particular the possibilities for their large-scale application and introduction over time.

Fischer-Tropsch liquids

All parts needed for a large-scale F-T plant (gasifier, cleaning system, and the F-T unit) do exist commercially. Only the demonstration of an integrated optimized system is needed. For the market introduction of FT-fuels no essential changes in cars or infrastructure are necessary; this is of outstanding importance. Furthermore, F-T oil is very clean; no aromatics and no sulfur are present. With a "mild" treatment with hydrogen, the characteristics of the fuel properties can be modified [5], opening applications for various markets (petrol, kerosene and diesel).

Production of FT-oil from biomass on short term is for small-scale systems still expensive yet [5]. In order to reach low cost levels, Tri-generation (production of a liquid, electricity and heat) is attractive [1]. For the long-term, for large-scale systems, a cost price in the range of 0.25 to 0.35 Euro (or $) /litre (Euro 6.9 to 9.7/GJ; 1 litre is 36.1 MJ) has been calculated [1, 6]. Assuming 3.6 Euro (or $)/GJ (Euro 68/t (d.m.)) for biomass feedstock; this last mentioned number is higher than most studies use, but it seems realistic for large scale imported biomass.

Ethanol

For ethanol the situation is more complicated. No well-established conversion routes do exist yet. Though research on this topic seems promising, no guarantee for success can be given. Under the present situation it is difficult to give hard numbers for the obtainable costs over time. Various (literature) sources report obtainable ethanol production cost from lignocellulosic biomass of around 7-8 $(or Euro)/GJ on the long term (based on the same assumptions as for F-T). These costs hold only if the on-going research program in the field of consolidated bio-processing, advanced pretreatment, elimination of seed reactors and fast rates is successful [7].

Comparison between the two liquids

A comparison between the two liquids is made on several aspects.
Costs. Only cost calculations for ethanol and F-T that are made without the use of subsidies are considered. Based on the analysis made, the F-T route seems the most promising for the short term. For the long term cost predictions for both liquids are in the same low range. Those cost levels can, however, for ethanol only be reached if fundamental breakthroughs are obtained.
Research. For the F-T route the main area of research is the optimal cleaning of the gas. However, the chance for a successful research program is very positive. This, because large-scale cleaning systems do exist for the production of liquids (SASOL (South Africa) for coal, Schwarze Pumpe (Germany) for all kinds of waste). For ethanol however the chance for a successful research program is uncertain.
Flexibility. For the market introduction it is important that several products for different applications can be delivered. The F-T process is quite flexible in this respect. Especially the production of hydrogen can become important in future. It is easy to transform, for low costs, a F-T plant that produces liquids into a plant that produces hydrogen.

Environment. For both applications holds that the introduction has to take place with low or no environmental burden. This means, one has to look at aspects like the energy balance, bio diversity (no monocultures), the use of pesticides, fertilizer, the mineral and carbon balance, emission of N_2O, etc. Also for these reasons woody or grassy materials has been chosen as feeding material.
Social acceptance. The social acceptance is of great importance and has to be dealt with carefully. Because there is no change in infrastructure at all, the F-T products may be easier accepted.
Sustainability. The introduction has to take place in a sustainable way. This means that costs, social aspects and environmental issues must show a positive development over time. However, studies do show that it is basically possible to introduce biomass for the large scale, modern energy supply in a sustainable way.

Conclusion
Taken all aspects together, for the short-term the F-T process seems to be the most attractive option for the market introduction of liquid fuels. For the longer term it is uncertain. However, the F-T process seems to offer the most positive perspective. One of the main reasons is that the F-T process makes the transition to hydrogen as an energy carrier quite easy.

These types of considerations are currently of crucial importance for programs like the Dutch GAVE program. This program is set up by the government to support short-term pilot- and demonstration activities financially. Longer-term trajectories are important to explore for insight in market perspectives and effective management and policies.

Selection of references
[1] Daey Ouwens C, Faaij A, Ruyter HP. Flexible, competitive production of electricity, heat, bio-fuels and ethanol by Tri-generation, 1st World Conference and Exhibition on Biomass for Energy and Industry, Sevilla, Spain, 5-9 June, 2000, (to be published)
[2] Daey Ouwens C, Faaij A. A comparison of liquid fuels made from food crops and from woody materials, Sustainable Energy: New challenges for Agriculture and Implications for land use; May 18-20, 2000; Wageningen, The Netherlands. Ed.: E. van Ierland, A. Oude Lansink and E. Schieman.
[3] An inventory of new gaseous and liquid energy carriers, Arthur D. Little International, Inc. Rotterdam December 1999; GAVE program three reports.
[4] Faaij A, Hamelinck C, Tijmensen M, van Hooidonk G. Long term perspectives for production of fuels from biomass, integrated assessement and RD&D priorities, final results Paper prepared for the 5th biomass conference of the America's, September 2001, Orlando, USA.
[5] Faaij A, Tijmensen M, van Hardeveld M, Hamelinck C.The production of Fischer Tropsch liquids and power through biomass gasification. Paper prepared for the 5th biomass conference of the America's, September 2001, Orlando, USA.
[6] Faaij A, van Ree R. Long term perspectives of Biomass Integrated Gasification with Combined Cycle technology, NOVEM, Utrecht 1998.
[7] Lynd, L., R., Elander, R., T. and Wyman, C., E., Likely Features and Costs of Mature Biomass Ethanol Technology, Applied Biochemistry and Biotechnology, 57/58, pp 741-761 (1996).